CORRECTION OF THIN CIRRUS EFFECTS AND CHARACTERIZATION OF CIRRUS RADIATIVE PROPERTIES FROM EOS/MODIS DATA

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INTRODUCTION

- The science community
- The proposed research
  - Thin cirrus detection and correction
  - Radiative transfer modeling
  - Contrail cirrus studies
- Schedules and time table
- Summary

The Science Community

- MODIS ocean and land groups for atmospheric corrections
- Climate research - cirrus clouds, contrail statistics and radiative properties

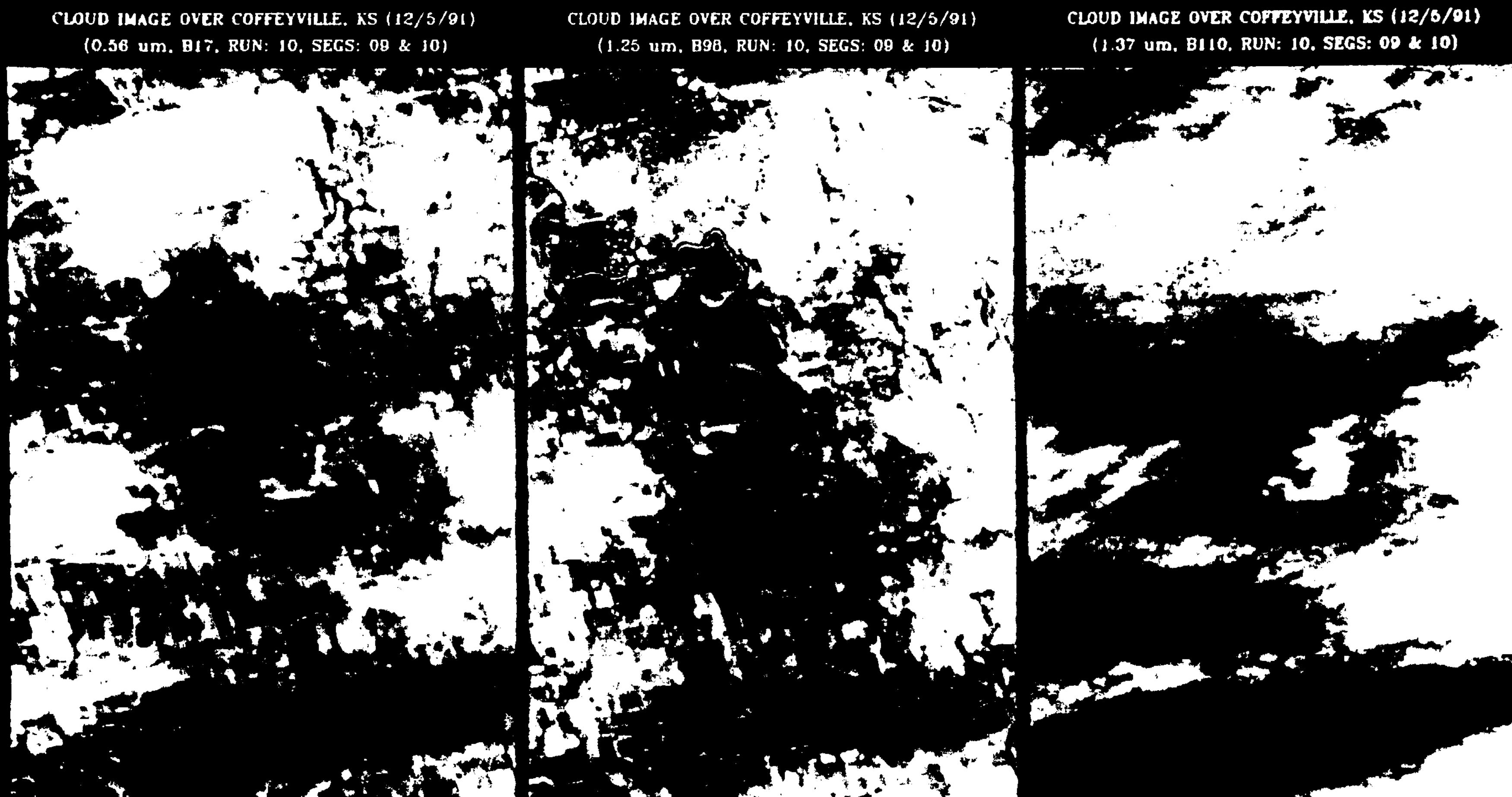
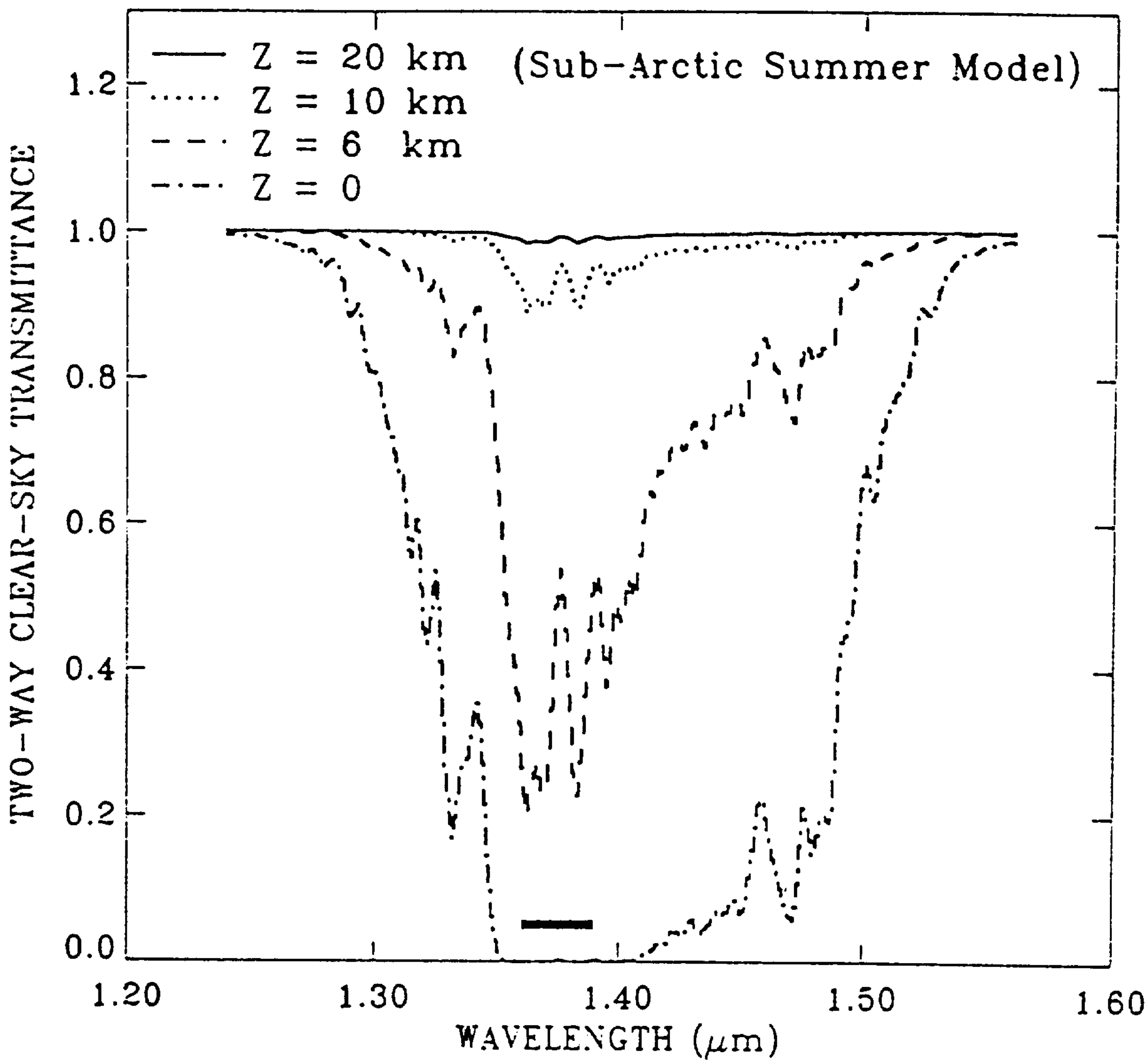


Fig. 1: Examples of AVIRIS images acquired over Coffeyville in southeastern Kansas on Dec. 5. 1991. Both the 0.56-μm and 1.25-μm images show surface features, while the 1.37-μm image shows only upper level cirrus clouds.


Z = 20 km
Z = 10 km
Z = 6 km
Z = 0
(Sub-Arctic Summer Model)
TWO-WAY CLEAR-SKY TRANSMITTANCE
WAVELENGTH (μm)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.20
1.30
1.40
1.50
1.60

Quantitative Use of The 1.375-μm Channel

- Cirrus removing/corrections

- Stratospheric aerosol monitoring after major volcano eruptions
  - first suggested by Robert Fraser at NASA Goddard, feasible, but not mentioned in our MODIS proposal.

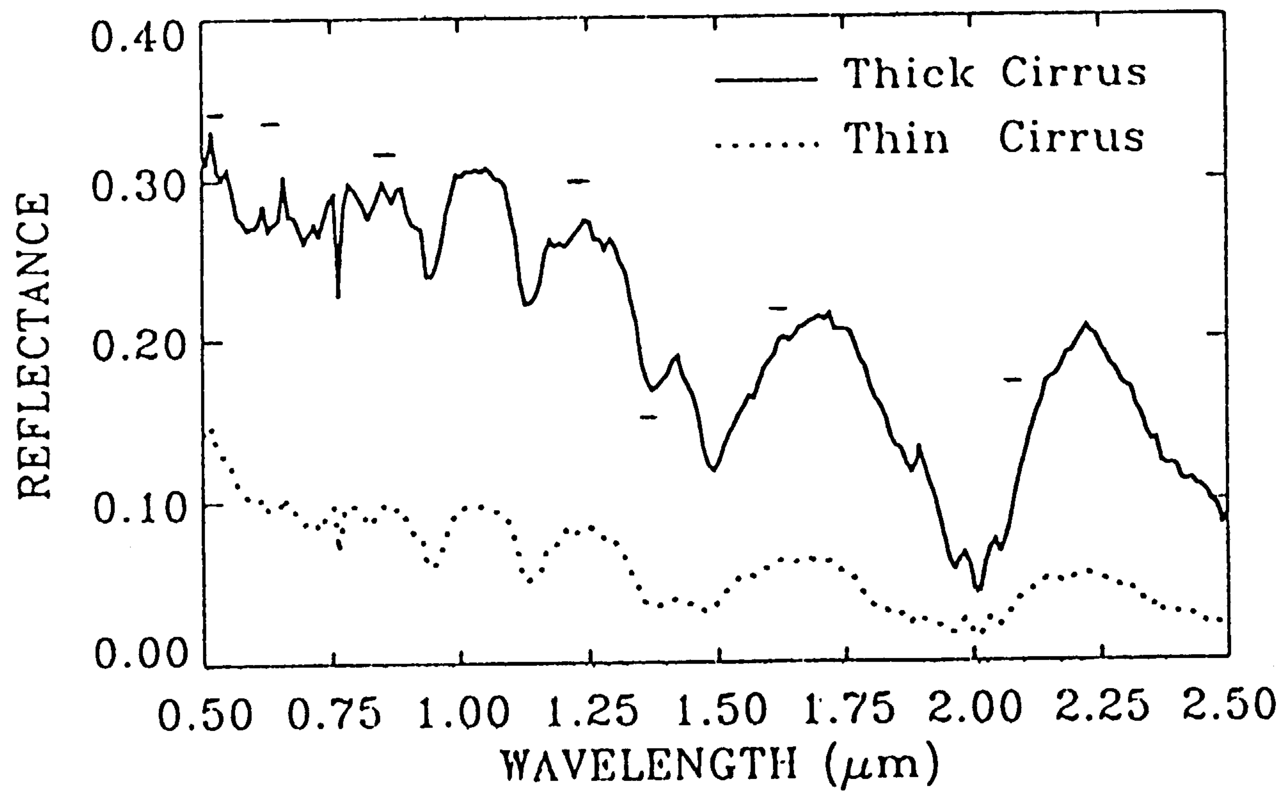


Fig. 3. Examples of AVIRIS spectra over thick and thin cirrus clouds. The spectra below 0.5 μm are not shown here due to calibration problems.

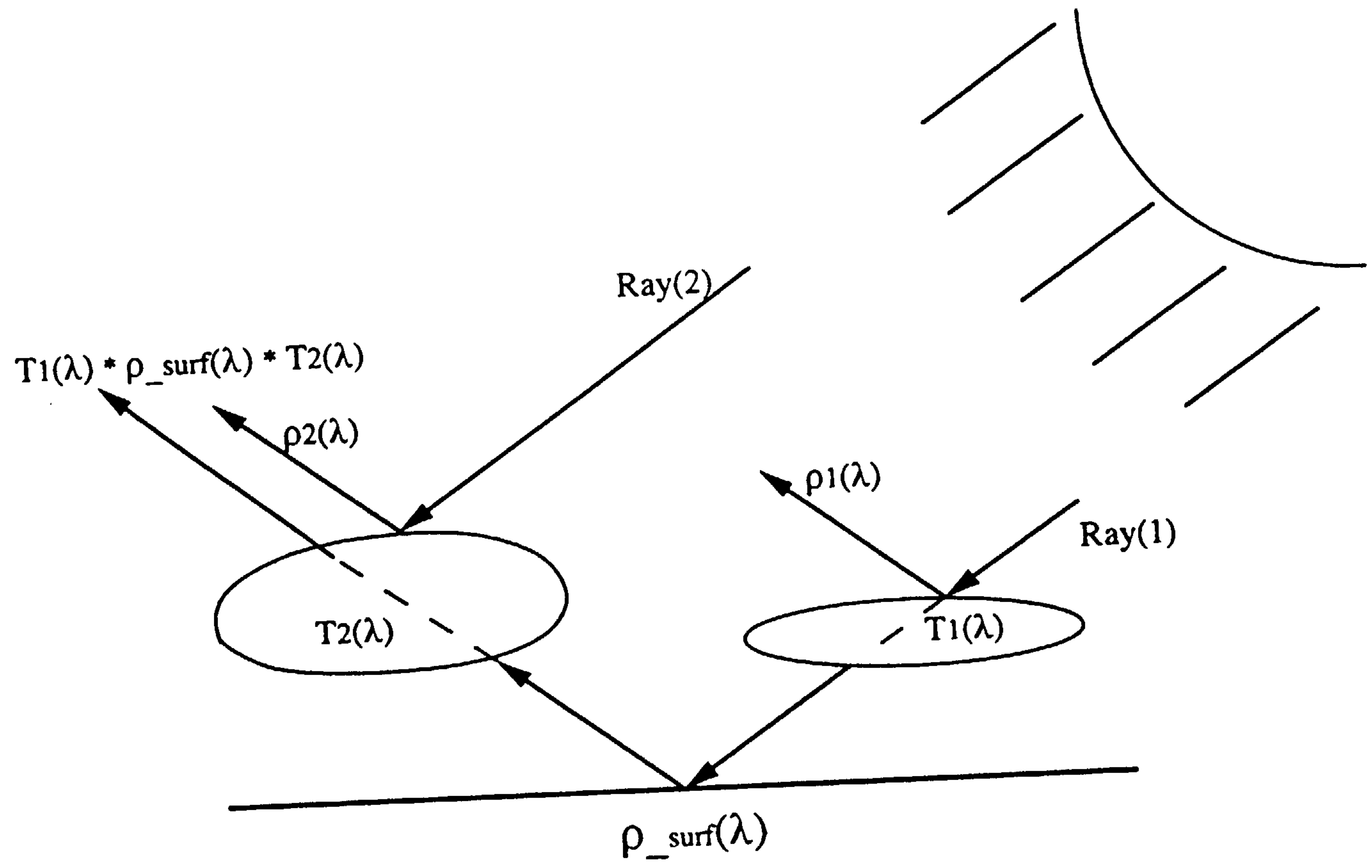


Fig. 4. An illustration of partially transparent and spatially inhomogeneous cirrus clouds. See text for detailed descriptions.

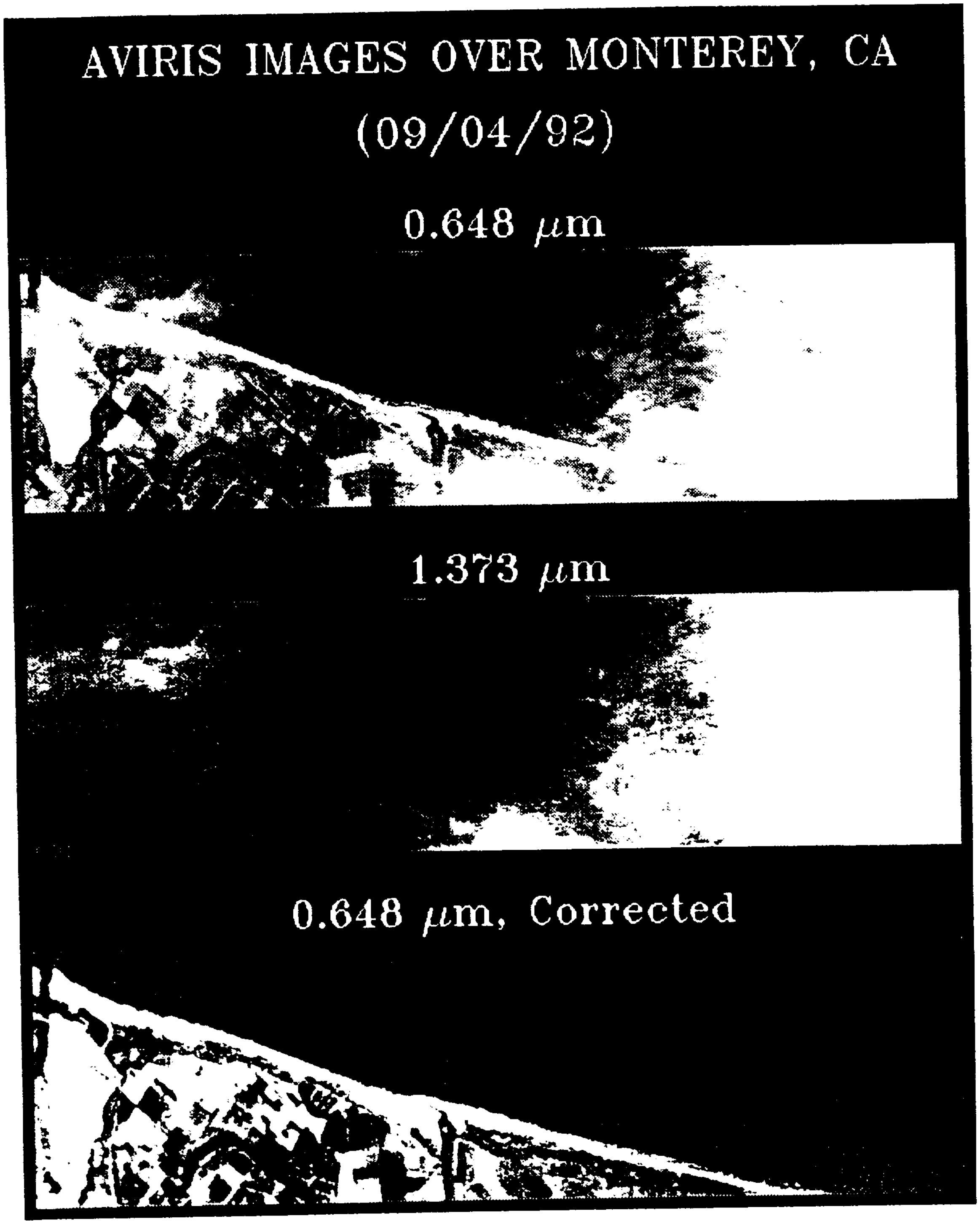


Fig. 5. AVIRIS 0.648 μm image (top plot), 1.373 μm image (middle plot), and cirrus path radiance corrected 0.648 μm image (bottom plot) over Monterey, California.

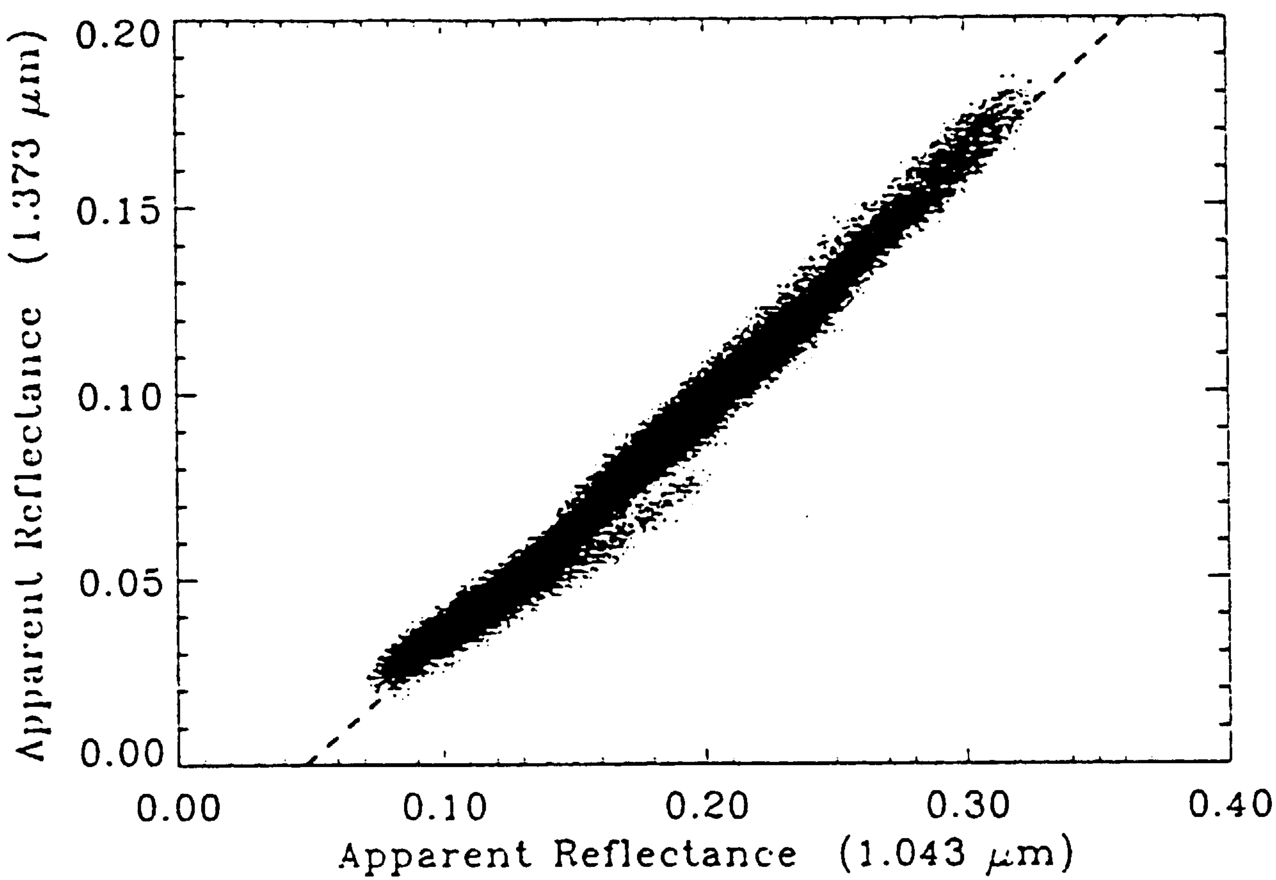


Fig. 6. A scatter plot of apparent reflectances at 1.373 μm versus those at 1.043 μm for cirrus clouds over water surfaces.

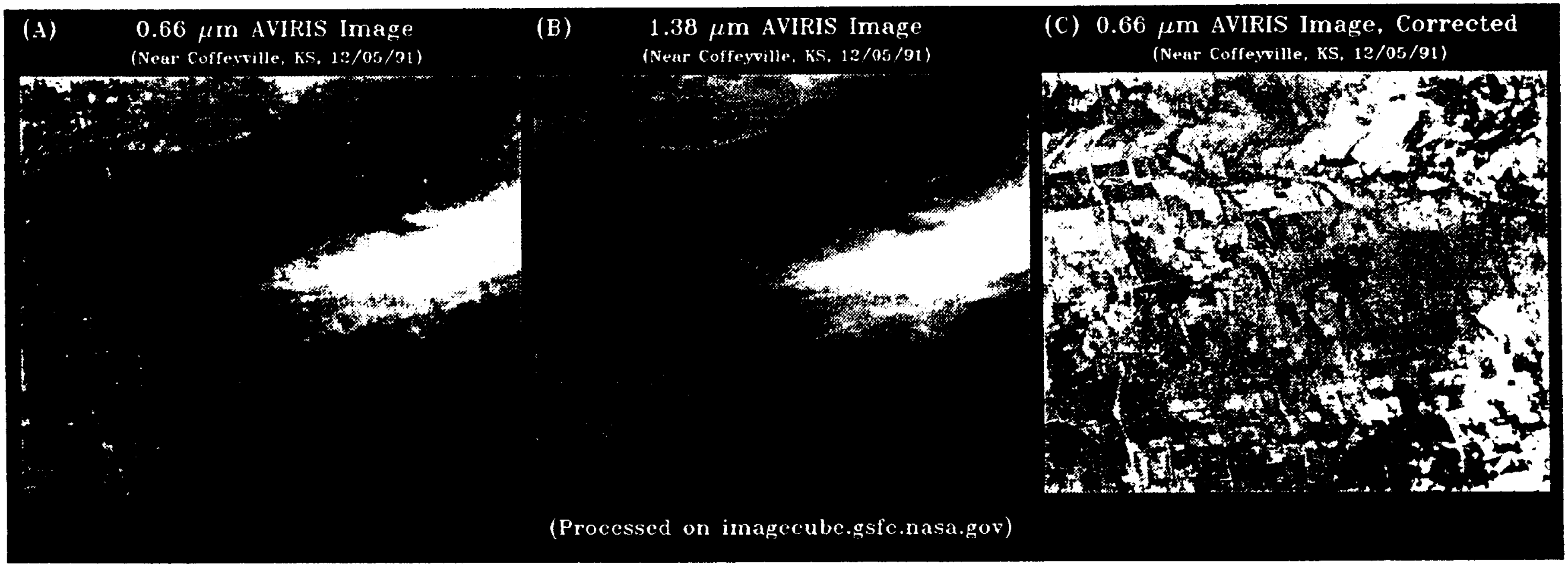


Fig. 7. AVIRIS 0.66 μm image (a), 1.38 μm image (b), and cirrus path radiance corrected 0.66 μm image (c) over an area near Coffeyville in southeastern Kansas.

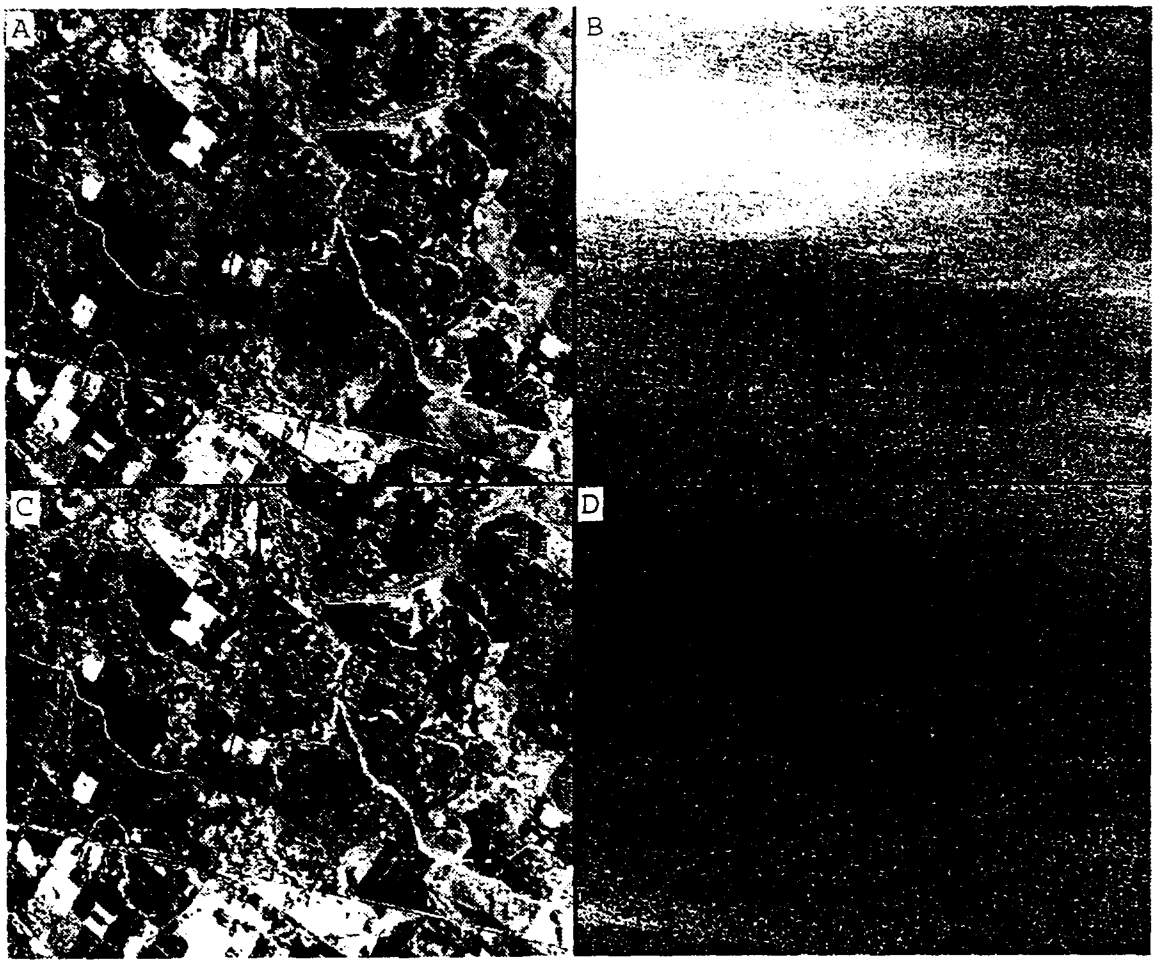


Fig. 8. (a) and (b) - the 0.87 µm and 1.38 µm images acquired with AVIRIS on July 8, 1992 during the 2nd overpass over an area near Gainsville, Florida, and (c) and (d) - similar to (a) and (b), except acquired during the 3rd overpass 20 minutes later over approximately the same area. The change in solar zenith angles between the two ER-2 overpasses was two degrees. The 0.87 µm images (a and c) appear to be very clear, but the 1.38 µm images (b and d) show variable thin cirrus effects.

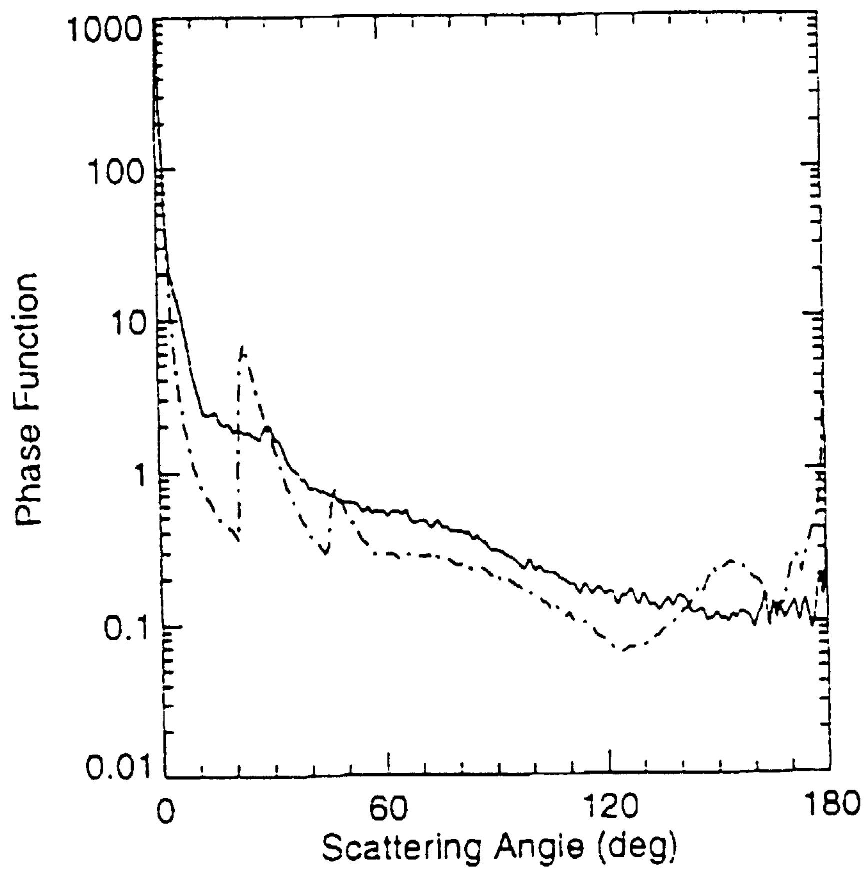
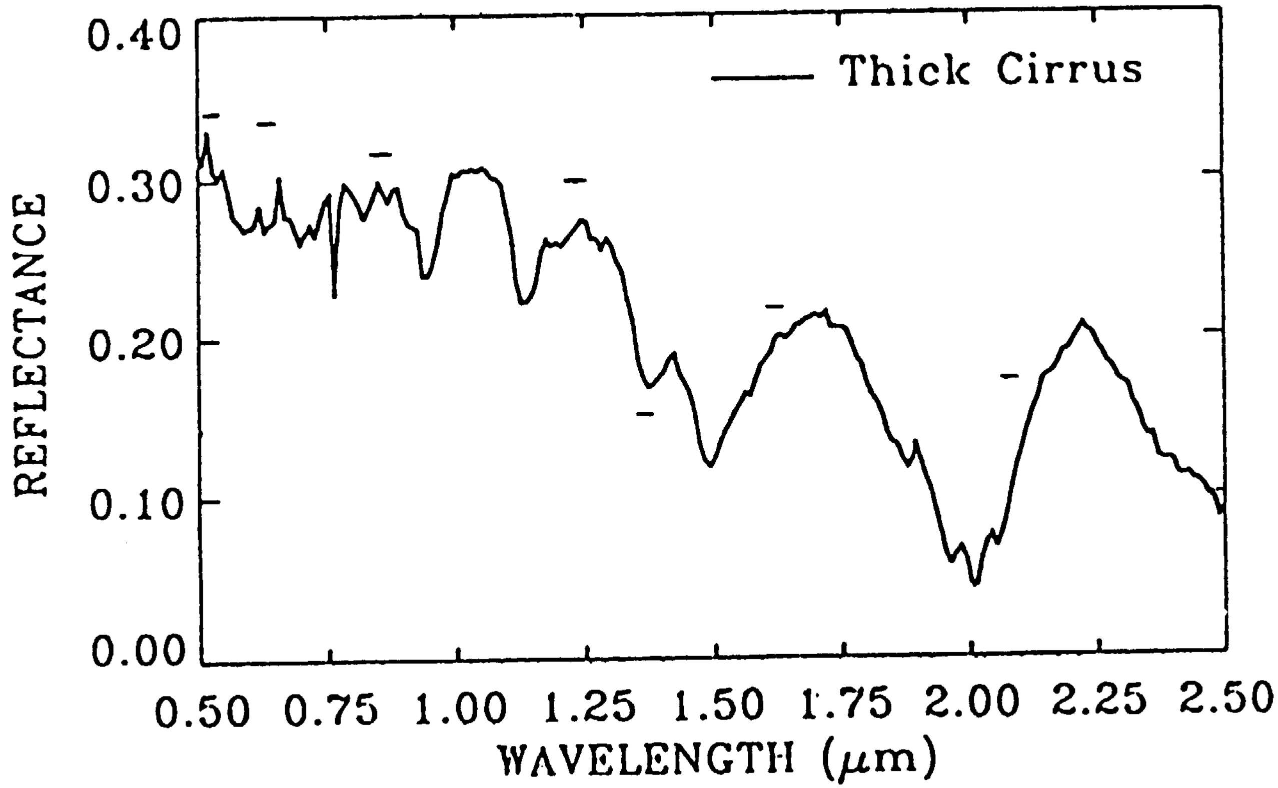
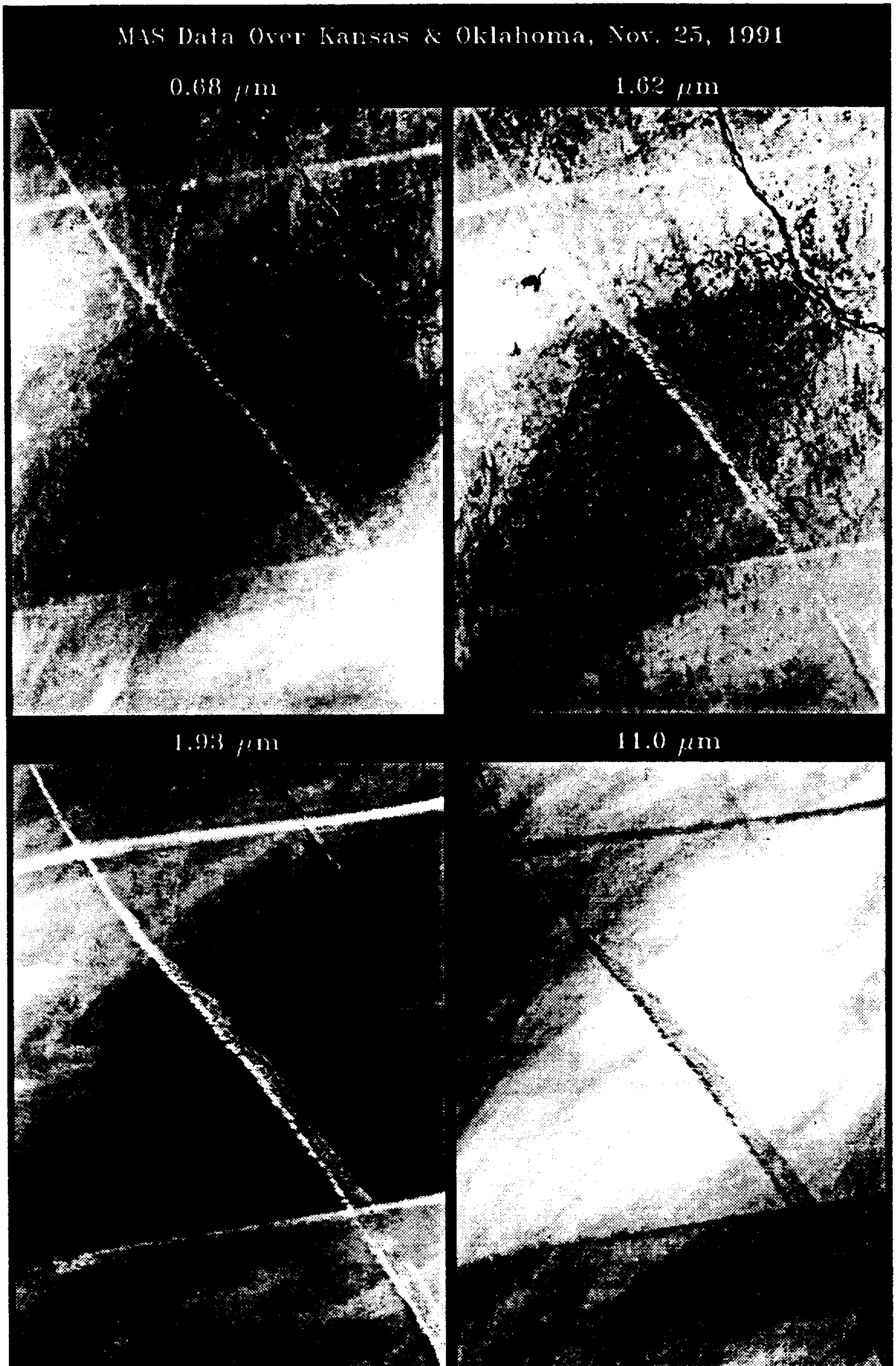


Fig. 12. Examples of phase functions computed for polydisperse, randomly oriented fractal (solid line) and hexagonal (dot-dashed line) crystals with effective radius of 30 μm.



Ice particle sizes can vary from a few microns to several hundreds microns. The scatter plots of

ρ(2.13 μm) vs ρ(0.86 μm) - for small ice particles
ρ(1.64 μm) vs ρ(0.86 μm) - for medium particles
ρ(1.24 μm) vs ρ(0.86 μm) - for large particles (> 100 μm)


MAS Data Over Kansas & Oklahoma, Nov. 25, 1991
0.68 μm
1.62 μm
1.93 μm
11.0 μm

Schedules and Time Table
(Preliminary)

	1996-97	1997-98	1998-99	1999-2000	2000-01
Gao (NRL)	Thin cirrus correction algorithms,AVIRIS, MAS data analysis.		MODIS + Field campaign data analysis, ice particle size retrievals, "emittance-albedo" algorithm, girded products for GCM applications.		
Wiscombe (NASA/GSFC)	2-D Monte Carlo radiative transfer modeling		Wavelet analysis, contrail cirrus climatology		
Mishchenko (SUNY/GISS)	Phase function calculations for ice particles having different sizes, shapes at multiple wavelengths, also phase functions of ice particles with impurities (e.g., soot, SO2) for modeling contrail cirrus radiative properties, multi-angle viewing camera data analysis				

Summary

- We proposed to develop techniques for operational removal of thin cirrus effects from MODIS data acquired over both the ocean and land areas. The techniques are simple, semi-empirical in nature, and with solid physics principles. The techniques will be tested with AVIRIS and MAS data, and should be able to be easily incorporated into the present MODIS ocean and land atmospheric correction algorithms.

- We proposed to develop and use theoretical models to simulate radiative transfer properties of thin cirrus clouds, including horizontal variability and nonspherical particle scattering, and to further guide the algorithm development.

- We also proposed to study the radiative properties of contrail cirrus clouds using MODIS data, assess the impact of contrail cirrus on earth's climate, and prepare a MODIS contrail climatology.